# THE MASSIVE STAR NEWSLETTER

formely known as *the hot star newsletter*

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No. 80 2003 November-December

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## Contents of this newsletter



## Working Group Matters

In September 2003 we held elections to fill six vacancies in the Organizing Committee of the Working Group on Massive Stars. The WG members elected Paul Crowther, Gloria Koenigsberger, Claus Leitherer, Phil Massey, Georges Meynet and Joachim Puls. The six new OC members are joining Philippe Eenens, Henny Lamers, Tony Moffat and Stan Owocki whose terms are still continuing. The OC then elected Claus Leitherer as the Chair for a three-year term.

The new OC is currently discussing several new scientific and organizational initiatives. Among them are:

1) Plans for large organized scientific projects, both observational and theoretical. The OC sees its role as a catalyst and focal point for such initiatives and urges interested WG members to be actively involved.

2) Support for a proposed major symposium on Massive Stars, to be held in 2006/2007.

3) Change of the name of the WG from ”Hot, Massive Stars” to ”Massive Stars” to emphasize the universal importance of massive stars in all parts of the upper HRD.

4) Improvements to the format of the Hot Star Newsletter. Future issues will be available as PDF files via web links.

5) Preparation of a mission statement and by-laws of this WG. Both are available on our website.

6) Generation of a new website. The new site will be much faster than the current one. It will be available online around February 2004. A notification of its availability will be sent out.

More details, in particular on issue 1), will be on the website when it is available.

On behalf of the Organizing Committee, I am sending you the best wishes for the holiday season and a prosperous 2004!

Claus Leitherer (Chair, WG on Massive Stars) – leitherer@stsci.edu

## Accepted Papers

# $\eta$ Car: the optical features at the 2003.5 low-excitation event

**A.M. van Genderen[1], C. Sterken[2], W. H. Allen[3] and W. Liller[4]**

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$UBV$ and $BVR$ photometry of $\eta$ Car during the 2003.5 low-excitation event – the considered periastron passage of a binary – is presented. The light and colour curves show a number of features, which were also seen at previous periastron passages: a light maximum of long duration with a superimposed flare-like event which is temporarily interrupted by an eclipse-like dip, and a steep decline in the $U-B$ color index. The $R$ brightness reached a minimum at the time of mid X-ray totality, probably implying that the H$\alpha$ emission line reached a minimum. The source of the optical flare-like event is probably not the same as the one causing the the X-ray radiation. It is tempting to consider the epoch of the $R$ minimum and the mid- X ray totality – which roughly coincides with the $UBV$ minimum – as the central moment of the 2003.5 low-excitation event.

**Accepted by A&A**
*Preprints from* `csterken@vub.ac.be`

# $\eta$ Carinae: the optical flare-like events during low-excitation events

**A.M. van Genderen[1], C. Sterken[2] and W.H. Allen[3]**

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The 1992.5 and 1998.0 low-excitation events of the possible binary in the core of $\eta$ Carinae show a conspicuous flare-like event in optical and near-ultraviolet light. These events last a couple of months and have a light amplitude of $0\overset{m}{.}1$–$0\overset{m}{.}2$ in $V$. Considering the presence of a dense (bi-polar) stellar wind, one explanation could be that some type of a hot area is created by an increased mass flow from the S Dor primary near the hypothetical periastron. These flare-like events are terminated by sharp dips. The magnitude differences between the underlying light source and the central light ('Component A') are derived. It turns out that they are fainter than Component A by $\sim 2\overset{m}{.}5$. The luminosity could be of the order of $10^5\,L_\odot$. It was possible to derive two new continuum values in the near-UV, reinforcing the impression derived from the HST fluxes that Component A has a very strong radiation peak in the Balmer continuum. This can probably be explained by the strong emission of the stellar wind.

**To appear in** 2003, A&A 412, L25
*Reprints from* `csterken@vub.ac.be`

## Optical CCD Observations of $\eta$ Carinae at La Plata Observatory

**E. Fernandez Lajus, R. Gamen, M. Schwartz,**
**N. Salerno, C. Llinares, C. Farina, R. Amorin, V. Niemela**

In 2003.5 Eta Carinae was expected to undergo an X-ray eclipse (Damineli et al., 2000). In the framework of an international campaign to obtain multi-wavelength observations of this event, we have obtained optical CCD images of Eta Carinae. Here, we present the B, V, R, I, data of Eta Car obtained before and during the X-ray eclipse.

**Accepted by IBVS**
**E-mail:** rgamen@fcaglp.unlp.edu.ar
**Web:** `http://arxiv.org/abs/astro-ph/0311437`

## A spectral and spatial analysis of $\eta$ Carinae's diffuse X-ray emission using CHANDRA

**Kerstin Weis[1,2,*], Michael F. Corcoran[3,4], Dominik J. Bomans[1], Kris Davidson[2]**

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The luminous unstable star (star system) $\eta$ Carinae is surrounded by an optically bright bipolar nebula, the *Homunculus* and a fainter but much larger nebula, the so-called *outer ejecta*. As images from the EINSTEIN and ROSAT satellites have shown, the outer ejecta is also visible in soft X-rays, while the central source is present in the harder X-ray bands. With our CHANDRA observations we show that the morphology and properties of the X-ray nebula are the result of shocks from fast clumps in the outer ejecta moving into a pre-existing denser circumstellar medium. An additional contribution to the soft X-ray flux results from mutual interactions of clumps within the ejecta. Spectra extracted from the CHANDRA data yield gas temperatures $kT$ of $0.6 - 0.76$ keV. The implied pre-shock velocities of 670-760 km/s are within the scatter of the velocities we measure for the majority of the clumps in the corresponding regions. Significant nitrogen enhancements over solar abundances are needed for acceptable fits in all parts of the outer ejecta, consistent with CNO processed material and non-uniform enhancement. The presence of a diffuse spot of hard X-ray emission at the S condensation shows some contribution of the highest velocity clumps and further underlines the multicomponent, non-equilibrium nature of the X-ray nebula. The detection of an X-ray "bridge" between the northern and southern part of the X-ray nebula and an X-ray shadow at the position of the NN bow can be attributed to a large expanding disk, which would appear as an extension of the equatorial disk. No soft emission is seen from the Homunculus, or from the NN bow or the "strings".

**Accepted by A&A**
*Preprints from* `kweis@astro.rub.de`
*or on the web at* `http://www.astro.ruhr-uni-bochum.de/kweis/publications.html`
`or http://xxx.lanl.gov/abs/astro-ph/0311308`

# HD 108: the mystery deepens with *XMM-Newton* observations

**Y. Nazé[1], G. Rauw[1], J.-M. Vreux[1], and M. De Becker[1]**

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In 2001, using a large spectroscopic dataset from an extensive monitoring campaign, we discovered that the peculiar Of star HD 108 displayed spectacular line variations. This strange behaviour could be attributed to a variety of models, and an investigation of the high energy properties of HD 108 was crucially needed to test the predictions from these models. Our dedicated *XMM-Newton* observation of HD 108 shows that its spectrum is well represented by a two temperature thermal plasma model with $kT_1 \sim 0.2$ keV and $kT_2 \sim 1.4$ keV. In addition, we find that the star does not display any significant short-term changes during the *XMM-Newton* exposure. Compared to previous *Einstein* and *ROSAT* detections, it also appears that HD 108 does not present long-term flux variations either. While the dramatic line variations continue to modify HD 108's spectrum in the optical domain, the X-ray emission of the star appears thus surprisingly stable: no simple model is for the moment able to explain such an unexpected behaviour.

Thanks to its high sensitivity, the *XMM-Newton* observatory has also enabled the serendipitous discovery of 57 new X-ray sources in the field of HD 108. Their properties are also discussed in this paper.

**Accepted by A&A**

*Preprints from* `naze@astro.ulg.ac.be`
*or on the web at* `http://vela.astro.ulg.ac.be/Preprints/P84/index.html`

# An *XMM-Newton* observation of the massive binary HD 159176

**M. De Becker[1], G. Rauw[1], J.M. Pittard[2], I.I. Antokhin[3,4], I.R. Stevens[5], E. Gosset[1] and S.P. Owocki[6]**

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We report the analysis of an *XMM-Newton* observation of the close binary HD 159176 (O7 V + O7 V). The observed $L_X/L_{bol}$ ratio reveals an X-ray luminosity exceeding by a factor ∼7 the expected value for X-ray emission from single O-stars, therefore suggesting a wind-wind interaction scenario. EPIC and RGS spectra are fitted consistently with a two temperature `mekal` optically thin thermal plasma model, with temperatures ranging from ∼2 to 6 $10^6$ K. At first sight, these rather low temperatures are consistent with the expectations for a close binary system where the winds collide well before reaching their terminal velocities. We also investigate the variability of the X-ray light curve of HD 159176 on various short time scales. No significant variability is found and we conclude that if hydrodynamical instabilities exist in the wind interaction region of HD 159176, they are not sufficient to produce an observable signature in the X-ray emission. Hydrodynamic simulations using wind parameters from the literature reveal some puzzling discrepancies. The most striking one concerns the predicted X-ray

luminosity which is one or more orders of magnitude larger than the observed one. A significant reduction of the mass loss rate of the components compared to the values quoted in the literature alleviates the discrepancy but is not sufficient to fully account for the observed luminosity. Because hydrodynamical models are best for the adiabatic case whereas the colliding winds in HD 159176 are most likely highly radiative, a totally new approach has been envisaged, using a geometrical steady-state colliding wind model suitable for the case of radiative winds. This model successfully reproduces the spectral shape of the EPIC spectrum, but further developments are still needed to alleviate the disagreement between theoretical and observed X-ray luminosities.

**Accepted by A&A**
*Preprints from* debecker@astro.ulg.ac.be
*or on the web at* http://vela.astro.ulg.ac.be/Preprints/P86/index.html

## Diffusion in stellar interiors: critical tests of three numerical methods

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We describe and discuss the properties of three numerical methods for solving the diffusion equation for the transport of the chemical species and of the angular momentum in stellar interiors. We study through numerical experiments both their accuracy and their ability to provide physical solutions. On the basis of new tests and analyses applied to the stellar astrophysical context, we show that the most robust method to follow the secular evolution is the implicit finite differences method. The importance of correctly estimating the diffusion coefficient between mesh points is emphasized and a procedure for estimating the average diffusion coefficient between a convective and a radiative zone is described.

**Accepted by Astronomy and Astrophysics**
*or on the web at* http://arXiv.org/abs/astro-ph/0312368

## A Galactic O-Star Catalog

**J. Maíz-Apellániz[1,2], N. R. Walborn[1], H. Á. Galué[3], and L. H. Wei[4]**

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We have produced a catalog of 378 Galactic O stars with accurate spectral classifications which is complete for $V < 8$ but includes many fainter stars. The catalog provides cross-identifications with other sources; coordinates (obtained in most cases from Tycho-2 data); astrometric distances for 24 of the nearest stars; optical (Tycho-2, Johnson, and Strömgren) and NIR photometry; group membership, runaway character, and multiplicity information; and a web-based version with links to online services (see http://www.stsci.edu/~jmaiz/GOSmain.html).

**Accepted by Astrophysical Journal Supplements**
*Preprints from* jmaiz@stsci.edu
*or on the web at* http://www.stsci.edu/~jmaiz/ps/Ocatalog/ms.pdf or astro-ph/0311196

# The Connection between W31, SGR 1806-20, & LBV 1806-20: Distance, Extinction, and Structure

**S. Corbel[1], Stephen S. Eikenberry[2]**

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We present new millimeter and infrared spectroscopic observations towards the radio nebula G10.0-0.3, which is powered by the wind of the Luminous Blue Variable star LBV 1806-20, also closely associated with the soft gamma-ray repeater SGR 1806-20, and believed to be located in the giant Galactic HII complex W31. Based on observations of CO emission lines and $NH_3$ absorption features from molecular clouds along the line of sight to G10.0-0.3, as well as the radial velocity and optical extinction of the star powering the nebula, we determine its distance to be $15.1^{+1.8}_{-1.3}$ kpc in agreement with Corbel et al. (1997). In addition, this strengthens the association of SGR 1806-20 with a massive molecular cloud at the same distance. All soft gamma-ray repeaters with precise location are now found to be associated with a site of massive star formation or molecular cloud. We also show that W31 consists of at least two distinct components along the line of sight. We suggest that G10.2-0.3 and G10.6-0.4 are located on the -30 km/s spiral arm at a distance from the Sun of $4.5 \pm 0.6$ kpc and that G10.3-0.1 may be associated with a massive molecular cloud at the same distance as the LBV star, i.e. $15.1^{+1.8}_{-1.3}$ kpc, implying that W31 could be decomposed into two components along the line of sight.

**Accepted for publication in Astronomy & Astrophysics**
**E-mail:** Stephane Corbel - corbel@discovery.saclay.cea.fr
**Web:** http://arxiv.org/abs/astro-ph/0311313

# Improved discretization of the wavelength derivative term in CMF operator splitting numerical radiative transfer

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We describe two separate wavelength discretization schemes that can be used in the numerical solution of the comoving frame radiative transfer equation. We present an improved second order discretization scheme and show that it leads to significantly less numerical diffusion than previous scheme. We also show that due to the nature of the second order term in some extreme cases it can become numerically unstable. We stabilize the scheme by introducing a mixed discretization scheme and present the results from several test calculations.

**Accepted by A&A**

*Preprints from* `baronnhn.ou.edu`

## Submitted Papers

# Be-star rotation: how close to critical?

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We argue that, in general, observational studies of Be-star rotation have paid insufficient attention to the effects of equatorial gravity darkening. We present new line-profile calculations that emphasize the insensitivity of line width to rotation for fast rotators. Coupled with a critical review of observational procedures, these calculations suggest that the observational parameter $v \sin i$ may systematically underestimate the true projected equatorial rotation velocity, $v_e \sin i$, by some tens of per cent for rapid rotators. The crucial implication of this work is that Be stars may be rotating much closer to their critical velocities than is generally supposed, bringing a range of new processes into contention for the elusive physical mechanism responsible for the circumstellar disk thought to be central to the Be phenomenon.

**Submitted to MNRAS**
**E-mail:** rhdt@bartol.udel.edu
**Web:** `http://arxiv.org/abs/astro-ph/0312113`

# On the Steady Nature of Line-Driven Disk Winds

**Nicolas A. Pereyra, Stanley P. Owocki, D. John Hillier, David A. Turnshek**

We perform an analytic investigation of the stability of line-driven disk winds, independent of hydrodynamic simulations. Our motive is to determine whether or not line-driven disk winds can account for the wide/broad UV resonance absorption lines seen in cataclysmic variables (CVs) and quasi-stellar objects (QSOs). In both CVs and QSOs observations generally indicate that the absorption arising in the outflowing winds has a steady velocity structure on time scales exceeding years (for CVs) and decades (for QSOs). However, published results from hydrodynamic simulations of line-driven disk winds are mixed, with some researchers claiming that the models are inherently unsteady, while other models produce steady winds. The analytic investigation presented here shows that if the accretion disk is steady, then the line-driven disk wind emanating from it can also be steady. In particular, we show that a gravitational force initially increasing along the wind streamline, which is characteristic of disk winds, does not imply an unsteady wind. The steady nature of line-driven disk winds is consistent with the 1D streamline disk-wind models of Murray and collaborators and the 2.5D time-dependent models of Pereyra and collaborators. This paper emphasizes the underlying physics behind the steady nature of line-driven disk winds using mathematically simple models that mimic the disk environment

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## In Proceedings

### Non-thermal emission from early-type binaries

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In this chapter, I review the properties of high-energy particles in the stellar winds of hot early-type stars. Relativistic electrons are responsible for the synchrotron radio emission observed from a subsample of these stars. Most of the objects in the latter category are found to be binaries and the collision between the stellar winds of the binary components is thought to play a crucial role in the acceleration of the relativistic electrons. The interplay between these high-energy electrons and the intense stellar radiation field could produce a substantial non-thermal emission at X-ray and $\gamma$-ray energies through inverse Compton scattering. Other mechanisms, such as $\pi^0$ decay might also contribute to the production of non-thermal emission from hot stars. These various effects could possibly account for some of the yet unidentified *EGRET* sources found to be correlated with OB associations in our Galaxy. Finally, I review recent results from *XMM-Newton* observations and discuss the prospects of forthcoming $\gamma$-ray observations with *INTEGRAL* and *GLAST*.

**To appear in: Cosmic Gamma-Ray Sources, edited by K.S. Cheng and G.E. Romero, Kluwer Academic Publishers, Dordrecht, 2004.**

*Preprints from* `rauw@astro.ulg.ac.be`
*or on the web at* `http://vela.astro.ulg.ac.be/Preprints/index.html`

## Meetings

### The Fate of the Most Massive Stars

### May 23 - 28, 2004
### Grand Teton National Park, Jackson Hole, Wyoming

During the past several years it has become increasingly apparent that eta Carinae and the rare objects like it, are telling us something about how the most massive stars end their lives.

Eta Carinae, the most massive and most luminous star in our region of the Milky Way, has received considerable attention in past decade, but the cause of its basic instability and its great eruption are still a mystery. It is a very evolved, highly unstable star with an initial mass probably greater than 100 Msun and we think it is nearing the end of its life. Eta Car is also the site of a spectacular bipolar nebula, the highest continuous mass loss rate for massive stars, and a peculiar 5.5 year spectroscopic cycle.

The recent extensive surveys for supernovae have also produced a growing class of objects that may not be true supernovae at all, the eta Car analogs or supernovae impostors.

The purpose of this meeting is to explore the behavior and characteristics of eta Car and its related objects, the origin of their instabilites, and the final stages of the most massive stars ($> 50-60$ Msun) and their relation to hypernovae and GRB's. We want to bring together people working on the most massive evolved stars with those studying the final stages, SNe and GRB's.

More information about the meeting including the location, accommodations, invited speakers, and program updates can be found at `http://etacar.umn.edu/symposium`. Meeting registration will also be available at this site beginning in January.

An abbreviated preliminary outline of the program is given below:

I. Eta Carinae 1800 to 2004: Multiple Eruptions and Multi-Wavelength Variability

II. The SNe impostors: Type IIn SNe's, SN61v, SN1994j (V12 in N2403), V1 in N2363, SN1997bs, the Pistol star, P Cyg, etc.

III. Eta Carinae – Close-Up of an Impostor: the central star (mass loss and wind, its evolutionary state), inner ejecta and Weigelt blobs (physics of the excitation processes), the Homunculus and outer ejecta (physics of the ejection)

IV. Physics of the Instability – the Eddington Limit and Beyond

V. Evolution - the effects of rotation, mass loss, metallicity, and the relation to the first stars

VI. Models for the final stages of the most massive stars. Relation to SNe types and hypernovae. Relation to GRBs. The collapsar model and rotation in the advanced stages.

Each session will include 3 or 4 invited talks of 30 to 40 minutes length followed by a discussion session of an hour or more. Part of each discussion will be focused around one or more outstanding questions or controversies for each topical session. All of the participants will know what these are in advance. Participants will be invited to to come prepared to "contribute" to the discussion. Because this is an open discussion, others may join in at any time with their own ideas, and other topics and questions may be added.

There will also be space for poster papers.

We intend to publish the proceedings in the ASP Conference Series. Funds have been requested from NSF to cover the publication costs.

Scientific Organizing Committee – Dave Arnett (Univ. Arizona), Kris Davidson (Univ. Minnesota), Gary Ferland (Univ. Kentucky), Alex Filippenko (Univ. California), Alexander Heger (Los Alamos Natl. Lab.), John Hillier (Univ. Pittsburgh), Roberta Humphreys (Univ. Minnesota), Andre Maeder (Geneva Observatory, Switzerland), and Kris Stanek (Harvard Univ.).

Send any questions to massive@etacar.umn.edu

## Massive Stars in Interacting Binaries
## August 16-20, 2004

We now have a web-site that interested people might like to consult:

http://www.astro.umontreal.ca/MSIB/

Tony Moffat & Nicole St-Louis, co-chairs of SOC/LOC